Australian Federalism: a CGE analysis of inter-government transfers

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Abstract

Using a general equilibrium model, we calculate that adoption of equal-per-capita funding of the States by the Commonwealth would raise Australian welfare by at least $150 million annually. Under the present funding system, governments in subsidized States exhibit a flypaper effect: money thrown at them sticks even though households would be better served if it were passed on through lower taxes. Our results are not very sensitive to variations in assumptions concerning population mobility and fiscal externalities. Only by making extreme assumptions concerning congestion or by eliminating flypaper effects could we produce results with annual welfare gains below $150 million.

Key words: fiscal federalism; flypaper effects; interstate mobility; congestion; fiscal externalities; applied general equilibrium.

JEL classification numbers: D58; H77; H73

1. Introduction

The Commonwealth government collects 81 per cent of tax revenue in Australia but the eight States[1] are responsible for 42 per cent of public outlays. This means that 23 per cent of the combined State and Commonwealth tax collection must be distributed from the Commonwealth to the States. In 2000-01 this amounted to $47 billion.

In performing the distribution, the Commonwealth is guided by the principle of fiscal equalization. As defined by the Commonwealth Grants Commission (CGC, 1999) this is the

> … entitlement of each State to funding from the Commonwealth such that, if each made the same effort to raise revenue from its own sources and operated at the same level of efficiency, each would have the capacity to provide services at the same standard.

Thus, under fiscal equalization, States with unavoidably high costs of providing public goods and/or inadequate tax bases are treated generously relative to other States.

For economic efficiency, a problem with a funding formula based on fiscal equalization is that it may lead to an inefficient spatial allocation of economic activity by encouraging labour and capital to locate in regions in which there are high costs of providing public services. Another problem is that the governments of heavily subsidized States may embark on expenditures with low payoffs.

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[1] We include the Australian Capital Territory (ACT) and the Northern Territory (NT) as States.

This would happen if these governments felt diminished responsibility for expenditures that are not financed by their own tax efforts.

On the other hand, Boadway and Flatters (1982), Petchey (1993 & 1995) and others make it clear that some fiscal equalization may be required for efficiency. Fiscal externalities, congestion, exogenous demographic disadvantage and access to revenue derived from land or mining rents can each cause an inefficient spatial allocation of factors of production. For example, lower taxes on mobile factors of production in a State with high revenue from mining rents could inefficiently attract residents. In the same way, higher taxes on mobile factors in States with unavoidable expenditures on items that do not benefit the bulk of taxpayers could inefficiently dissuade people from living in these States as they seek to avoid partially footing the bill for such expenditures. In both cases, transfers may be required for an efficient spatial allocation of factors of production.

In this paper we analyze the efficiency effects of changes in the existing funding arrangements between the Commonwealth and the States by applying the Commonwealth/State funding (CSF) model. This is a general equilibrium model encompassing the factors of relevance to this issue including: interstate differences in tax bases and unit costs of State public goods; factor mobility; congestion; State government spending and taxing behaviour incorporating the possibility that governments in subsidized States embark on expenditures with low benefit/cost ratios; fiscal externalities; and non-discretionary expenditures in each State associated with special national responsibilities.

The paper is organized as follows. In the next section we work through the CSF theory. This is followed in section 3 by a description of the model's database. Section 4 contains results from seven CSF simulations. Concluding remarks are presented in section 5.

2. The theory of CSF

In this section we explain the CSF equations, listed in Table 1.

2.1. Labour inputs, wage rates and rental rates in mining

The first 6 equations in Table 1 are concerned with the use of labour time. Labour should be thought of as a composite factor consisting of hours of effort combined with the use of physical capital. A good picture to have in mind is that workers carry their own tools.

Equation 1 relates State i's use of labour (L_{1i}) in the production of non-mining private goods to the quantity of production (Y_{1i}) via an exogenously given coefficient (A_{1i}). As can be seen from Table 2, production of non-mining private goods is the major labour-absorbing activity in all States except the ACT where production of goods for the Commonwealth government is the major user of labour.

Equation 2 specifies a Cobb-Douglas production function for mining output. In a rearranged form this equation relates the use of labour in State i in the mining industry (L_{2i}) to: an exogenous technology coefficient (A_{2i}); mining output (Y_{2i}); and an exogenously given resource endowment (R_i). The Cobb-Douglas exponents (the α_is) were set at the labour shares (returns to work hours and physical capital) in value added in mining for each State.

Equations 3, 4 and 5 use exogenously given coefficients (A_{3i}, A_{4i} and A_{5i}) to relate the use of labour in each State (L_{3i}, L_{4i} and L_{5i}) in the production of government goods to the quantities produced (C_{3i}, C_{4i} and C_{5i}). These quantities are also the quantities consumed. The three categories of government goods are: those produced for the Commonwealth government (C_{5i}, heavily concentrated in the ACT); discretionary goods produced for the State governments (C_{3i}); and non-discretionary goods produced for the State governments (C_{4i}). We assume that the bulk of State government consumption is discretionary (the C_{3i} goods): the State government is free to vary the quantities that it provides of education, transport, law enforcement, environmental supervision, health services and most other services. However, there are some expenditures, such as administration of native title and other obligations to indigenous people, over which the State government has little control. These are the C_{4i} goods. As we will see, C_{3i} is determined in CSF as the outcome of an optimization problem solved by State government i, whereas C_{4i} is treated exogenously. In most simulations we assume that category 4 accounts for about 12 per cent of State government expenditures, with a significantly higher percentage (20) in NT and a significantly lower percentage (7) in the ACT. However, because the distinction between C_{3i} and C_{4i} is not clear cut, in our application of CSF we conduct a sensitivity analysis by varying the proportions of State government expenditures devoted to categories 3 and 4. Finally, we assume that all State government consumption in State i is satisfied by goods produced within State i.

In equation 6 we allow work-related travel time (L_{6i}). In deriving the equation we assume that people in each State are spread evenly over a circular area and that each day they travel to the centre of the circle. As shown in the Appendix, the circle analogy suggests a value for the exponent γ of between 1.5 and 2.5. The lower value emerges when we assume that each person's travel time is proportional to the distance of the person's residence from the centre and is independent of the number of people travelling. The higher value emerges when we assume that a person's travel time depends not only on distance from the centre but also on the number of people sharing his or her travel channel. In most of the simulations in section 4 we set γ at 1.5. However, we provide a sensitivity simulation in which γ is 2.5.

Equation 7 calculates the total use of labour (L_i) in each State, including travel time. Equation 8 then computes leisure time in each State (C_{2i}) as the difference between total potential labour (represented by the population, N_i) and total labour usage. As can be seen from Table 2, we scaled the total population (N) to embody the assumption that in the initial situation the average Australian worker devotes one third of potential labour time to leisure. Total population for Australia is defined in equation 9 as the sum of the State populations.

Equation 10 determines pre-tax wage rates. We choose units so that a unit of private goods (either non-mining or mining) has a price of 1. This means that State i's pre-tax wage rate (payment for a labour hour and its associated capital) must be $1/A_{1i}$, which is the value of the marginal product of labour in the production of non-mining private goods. The pre-tax wage rate is also the value of the marginal product of labour in mining. This leads to equation 11. Equation 12 defines the rental rate (R_i) on mining resources in State i by determining total rental payments (Q_iR_i) as the non-wage share ($1-\alpha_i$) of the value of mining output.

2.2. Household utility, the household budget, household demands for private goods and leisure, and the money equivalent of aggregate utility

Equation 13 is the utility function for households in State i. This is a Cobb-Douglas function of per capita consumption of private goods (C_{1i}/N_i), per capita consumption of leisure (C_{2i}/N_i), and effective per capita consumption of State government discretionary goods (C_{3i}/N_i^{θ}). If the parameter θ equals 1 and there is a 1 per cent increase in the population of a State, then a 1 per cent increase in the resources devoted to the production of State discretionary goods is required to maintain the initial effective level of provision. However, for some discretionary goods there may be economies of scale in production and/or non-rival aspects of consumption. This can be recognized by using values of θ of less than 1. By excluding non-discretionary State government goods from household utility, we assume that the provision of these goods is merely an unavoidable necessity.

Household demands in State i for private goods and leisure are derived by maximizing household utility subject to a budget constraint. The budget is given by equation 14 which defines the amount of income (B_i) that households in State i can devote to the consumption of private goods and to leisure. In calculating this amount, we include the total potential value of paid labour, i.e. the after-tax wage rate (W_{ti}) times the total amount labour that could be devoted to paid employment (N_i – L_{6i}). We can think of leisure as being the consumption of a unit of labour by households through not supplying it for paid employment. Thus the price of a unit of leisure is W_{ti}. In addition to the total potential value of paid labour, household income in State i includes two other positive terms. The first is Commonwealth government benefits which are modelled as an exogenous rate ($BENRATE_i$) times population. The second is mining rentals accruing to residents of State i, consisting of State i's part of all the after-tax mining rentals (NMR) generated in Australia. This part is NMR multiplied by the Australian share of mining rentals (S, about 0.5) and by State i's population share. We assume that there is no connection between the State in which a mining activity is located and the State in which the rents accrue. The final term in the household budget is a negative item. This is State taxes associated with ownership of land and dwellings and is calculated as the rate of tax (T_{3i}) times the rental value of land and dwellings (OD_i). Only the tax associated with ownership of land and dwellings appears in equation 14. OD_i itself is both an income and an expenditure and can be left out of the household's budget constraint.

Equations 15 to 17 tie up three loose ends introduced in the definition of B_is: the definitions of after-tax wage rates (the W_{ti}s), after-tax mining rentals (NMR) and the rental values of land and dwellings (the OD_is). Equation 15 defines W_{ti} in each State as the pre-tax wage rate less State and Commonwealth taxes applying to factor incomes (recall that in CSF the wage rate is the return to hours of work and to physical capital). In estimating the State tax rates (the T_{1i}s) we included all State taxes and all other own-source State revenue except revenue derived from taxing housing, land and mining rents. In estimating the Commonwealth tax rate (T_C) we included all sources of Commonwealth revenue. Equation 16 defines NMR as the sum over all States of mining rentals less State taxes which are charged in State i at the rate T_{2i}. Equation 17 defines OD_i as the sum of two parts. The first part is the rental value of buildings. We assume that this reflects the population and the cost of building which we assume is proportional to the pre-tax wage rate (W_i). The second part is the rental value of unimproved land. Applying our theory of travel times and the circular distribution of State populations, we find in the Appendix that the value of land is proportional to the after-tax wage rate and to the population raised to the power γ.

Having defined the budget (B_i), we obtain the demand functions for private goods and for leisure by choosing C_{1i} and C_{2i} to maximize U_{hi}, defined by equation 13, subject to

$$C_{1i} + W_{ti} * C_{2i} = B_i \quad . \tag{2.1}$$

With δ_{1i} plus δ_{2i} set (without loss of generality) at 1, we obtain equations 18 and 19. Consistent with these equations, δ_{1i} and δ_{2i} are set at the database shares of the household budget devoted to private goods and to leisure.

For evaluating a proposed policy change it is necessary to include in CSF a measure of changes in total utility. This is done in equation 20 which computes changes in aggregate utility (del_U_{tot}) as a weighted sum of the changes (del_U_{hi}) in the utility of the typical household in each State. The weights have two components. The first is N_i^{ave}, the population in State i averaged across its initial value and its final value (that is its simulated value after the imposition of the proposed policy change). The role of N_i^{ave} is to convert changes in per capita utility in each State into changes in total utility. The second weighting component, A_{ui} is used to convert utility changes into equivalent money changes. The value of A_{ui} was derived from a CSF simulation in which we computed the effect on U_{hi} of a $1 gift per capita from foreigners to the households in State i, holding constant all tax rates, the provision of government goods and the populations of each State. If this simulation showed an increase of x units in U_{hi} (i.e. $del\_U_{hi} = x$) we set A_{ui} at 1/x.

The variables N_i^{ave} and del_U_{tot} are related to initial ($NBASE_i$ & $UBASE_i$) and final (N_i and U_{hi}) values of population and utility through equations 21 and 22.

2.3. State government utility, State government budget and State government determination of expenditures and taxes

Equation 23 defines the utility function for the government of State i. Each State government is concerned with the welfare of its households which it recognizes as depending on their consumption of private goods, leisure and State government discretionary goods. The State government's function for evaluating household welfare coincides with the household utility function except for the value of the exponent on effective per capita consumption of State government discretionary goods (δ_{3gi} for State government i and δ_3 for households). Before discussing δ_{3gi} and δ_3, we show how the State utility functions are used.

The role of these functions is in determining the expenditure and tax behaviour of the State governments. We assume that the government of State i:

chooses C_{3i}, T_{ii} and B_i to maximize

$$(\delta_{1i}/N_i)^{\delta_{1i}}(\delta_{2i}/[N_i W_i(1-T_{1i}-T_C)])^{\delta_{2i}} B_i \left(C_{3i}/N_i^{\theta}\right)^{\delta_{3gi}} \quad (2.2)$$

subject to

$$B_i - W_i(1-T_{1i}-T_C)(N_i - L_{6i}) - BENRATE_i N_i - S*NMR(N_i/N) + T_{3i}OD_i = 0 \quad (2.3)$$

and

$$SB_i + A_{3i}W_iC_{3i} + W_iL_{4i} - T_{1i}W_i\left[N_i - L_{6i} - \delta_{2i}B_i/\left(W_i(1-T_{1i}-T_C)\right)\right] - T_{2i}Q_iR_i - T_{3i}OD_i - H_i = 0 \quad (2.4)$$

The objective function, (2.2), is the State government utility function with C_{1i} and C_{2i} substituted out via equations 18 and 19, and with the after-tax wage rate (introduced by this substitution) replaced by the RHS of equation 15. The first constraint, (2.3), is a rearranged version of the household budget equation (equation 14). The second constraint, (2.4), is a combination of equations 24, 25 and 26. Equation 24 defines the budget surplus for State i (SB_i) as own-source revenue (SR_i) plus the Commonwealth grant (H_i) less State government expenditure (SE_i). Equation 25 defines own-source revenue as the sum of State taxes on labour (factor income), mining rents and land and buildings. Equation 26 defines SE_i as expenditure on discretionary and non-discretionary goods. We represent expenditure on discretionary goods as the cost per unit ($A_{3i}W_i$) times the number of units (C_{3i}). For non-discretionary goods, we are not concerned with the number of units and we can express expenditure simply as the unavoidable cost of the labour input (W_iL_{4i}).

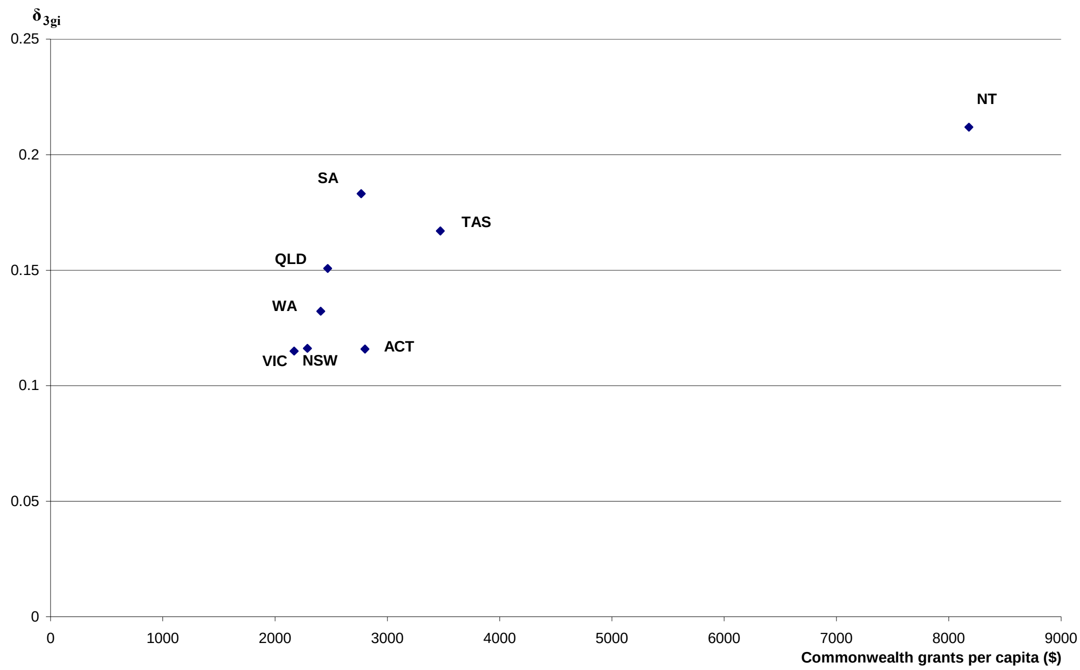
In problem (2.2) to (2.4), State government i understands that its tax decisions affect the household budget (B_i) and the after-tax wage rate (W_{ti}), and that household consumption of private goods and leisure respond according to equations 18 and 19. Taking these responses into account, the State government chooses C_{3i}, (and consequently its tax policy and the household budget) to maximize the State government's version of household welfare subject to two budget constraints: the households' budget constraint and the State government's own budget constraint. For simplicity we restrict the State government's choice of tax instruments to the tax on factor income, T_{1i}. For all State governments this is the overwhelming source of own-state revenue. We also assume that in deciding its expenditure and tax policies, the State government does not take into account the effects of its actions on pre-tax wage rates, pre-tax mining rentals, pre-tax rentals on land and buildings, population, and its Commonwealth grant (H_i). It is sometimes argued [see for example Swan and Garvey (1995) and Petchey (2001)] that the present formula used by CGC gives State governments incentives to modify the compositions of their expenditures and tax collections to affect their H_is. Quantitative investigation of this possibility would require a more disaggregated treatment of taxes and expenditures than that currently in CSF.

By treating (2.2) to (2.4) as a Lagrangian problem we can derive conditions for a solution. These conditions are equations 27, 28 and 29. Through the adoption of these equations in CSF, together with the household and State government budget equations (equations 14 and 24 to 26), we impose the assumption that State governments behave as if they are constrained optimizers in accordance with (2.2) to (2.4).

As mentioned earlier, we set the exponents δ_{1i} and δ_{2i} in the utility functions for households and the government in State i at the shares of private goods and leisure in household consumption. In setting a value for the exponent δ_{3gi} in the government utility function for State i, we used the optimality conditions 27, 28 and 29. From our database we have values for all of the variables and parameters appearing in these equations with three exceptions: Λ_{1i}, Λ_{2i} and δ_{3gi}. Values for Λ_{1i}, Λ_{2i} and δ_{3gi} can be determined by solving the three equations. The δ_{3gi} values obtained in this way are shown in Table 2 and plotted in Figure 2.1 against Commonwealth grants per capita.

On the basis of Figure 2.1, we conclude that there is a tendency for governments in States receiving large per capita grants to behave as if they place a high valuation on State-government-provided goods. Consistent with the relatively similar cultural and economic characteristics of the populations of all Australian States, we assume that typical households in each State have similar views of State-provided goods. To implement this assumption we adopt the same exponent (δ_3) for State-government goods in the household utility functions for all States. The value we choose for δ_3 is the minimum value revealed for the δ_{3gi}s, that is the value for δ_{3gVIC}. We choose the minimum value to reflect the idea that decision makers in State governments (politicians and public servants) benefit in terms of career and prestige from the provision of State-government goods.

Figure 2.1. Revealed State government preference indicator (δ_{3gi}) for State government goods and Commonwealth grant per capita



A way to account for grants affecting state government preferences is to acknowledge that whilst voters are concerned about both public expenditures and tax levels they lack the information or inclination to draw a strong link between the two. If this were the case a government in receipt of a larger grant would not be under great pressure to cut taxes to the degree that consumers would like. Thus it would behave as if it placed a higher valuation on State government expenditures than do households.

2.4. Commonwealth grants to the States

Proposed changes in Commonwealth grants per capita are introduced in CSF as shocks to the FHN_is in equation 30. To ensure that the shocks do not affect the total grant H (determined by an add up in equation 31), we exogenize H and allow FFH to adjust endogenously.

2.5. Population movements across the States

A potentially important aspect of changes in Commonwealth grants across the States is the induced effect on State populations. Under any change in the system we would expect that States receiving a more generous treatment would gain population at the expense of other States. We handle this issue in CSF through equations 32 to 38.

The picture to have in mind in interpreting equations 32 to 38 is the following. Every year x per cent (say 10 per cent) of Australian households in each State are potentially mobile. They assess their prospects in their current State and in all other States and decide whether or not to make a move. In assessing their prospects they calculate their potential incomes in all States. On average, the mobile households calculate their potential income in State i as B_i^m, given in equation 32. If it were to locate in State i, then the average mobile household anticipates that it would receive: the average mining rentals accruing to Australian households and the average Commonwealth benefits accruing to households in State i. It would also anticipate being able to sell or rent out its existing residence giving it an income equivalent to the average after-tax rental on land and buildings accruing to Australian households. The final item in the mobile household's potential income in State i is the value of its full labour time (one unit), which can be devoted to either work or leisure, less the value of travel time ($W_{ti}*LB_{6i}$). As reflected in equation 33 where we compute LB_{6i}, we assume that mobile households locate on the boundary of cities.[2] This assumption is convenient rather than limiting. If mobile households locate on the interior of the city, then their welfare (and incentive to move) is unaffected: they swap travel savings for extra rent.

Equations 34, 35 and 36 specify the consumption of private goods (C_{1i}^m), the consumption of leisure (C_{2i}^m) and the effective consumption of State-government discretionary goods (C_{3i}^m) that the average mobile household would expect to enjoy if it were to locate in State i. Equation 37 translates these expected consumption level into an expected utility level (U_i^m) and, with FUM_i set exogenously on 1, equation 38 implies that mobile households distribute themselves in such a way that their anticipated utility levels are the same in all States.

If the parameter d in equation 37 is set at 0, then expected utility of a mobile household locating in State i is the utility that would be received by any household in State i with consumption levels C_{1i}^m, C_{2i}^m and C_{3i}^m. However with d equal to 0, CSF implies unrealistically large population movements in response to seemingly small policy shocks favouring one State or another. By setting d at values greater than zero, we introduce a stay-at-home bias, which damps interstate mobility.

[2] The theory underlying equation 33 is set out in the Appendix.

2.6. Commonwealth budget

Equation 39 defines the Commonwealth budget surplus (FB) as tax collections less outlays consisting of purchases of goods, grants to the States and payments of benefits to households. In simulations we fix the Commonwealth budget surplus (FB) exogenously and allow endogenous adjustments in T_C.

3. The CSF database

In applying a general equilibrium model such as CSF, the first step is to create a database from which we can deduce an initial solution. This is a set of values for the variables that, in conjunction with the parameter values, satisfy all the equations. Simulation experiments then consist of moving the exogenous variables away from their values in the initial solution and computing the effects on the endogenous variables.

The initial solution for CSF is drawn from data for 2000-01. In this section we provide short notes on these data, concentrating on the components in Table 2.[3]

The first row of Table 2 contains pre-tax wage rates (W_i). These are the returns to the labour/capital (LK) composite and were obtained from ABS data by subtracting the rental value of mining and ownership of dwellings from total factor income and dividing by employment. The W_is are normalized by setting W_{NSW} equal to one.

To derive tax rates (rows 2, 6, 7 and 3), we obtained ABS and CGC data on tax-revenues and then divided by CSF tax bases. There is considerable variation across the States in the tax rates generated this way. For example, the tax rate on the LK composite is 3.6 per cent in ACT and 7.0 per cent in Queensland. The low rate in ACT reflects the exemption of government employment from payroll taxes, while the high rate in Queensland reflects substantial revenue from public enterprises which, in our aggregated approach, are treated as tax revenues.

Returns to buildings and unimproved land (rows 8 and 9) were obtained by splitting ABS data on actual and imputed income from ownership of dwellings. We assumed that the split for Victoria is 50-50 and that average house quality is the same across States ($A_{7i} = A_7$ for all i). This gave us the entries in row 8. The entries in row 9 were obtained as a residual.

In allocating returns to the LK composite across different uses (rows 11 to 16) we first derived W_iL_{2i} by subtracting mining rent (row 5, obtained from CGC data) from ABS estimates of mining income by State. Deflating by wages in each State then gives L_{2i}.

Use by the State governments of the LK composite (L_{3i} plus L_{4i}) was derived from data on State expenditures in CGC 2001 Update. We assume that aggregate expenditure on discretionary goods (W_iL_{3i}) is \$74.03b and on non-discretionary goods (W_iL_{4i}) is \$9.99b. In making this split, we looked at detailed expenditure data by State in CGC Working Papers 2001, Vol. 3, Table 4.22. Expenditures that we allocated to the non-discretionary category are those that the CGC identifies as having high representations of the characteristics: Socio-Demographic Composition; Land Rights & Native Title; and National Capital.

Use by the Commonwealth government of the LK composite (L_{5i}) was derived from expenditure data (W_iL_{5i}) by State in the Review of Commonwealth-State Funding Background Paper, 2002 supplemented by data from the ABS State accounts.

[3] The complete database and a more comprehensive description is available from the authors.

In deriving W_iL_{6i}, we assumed that, on average, workers spend 11 per cent (about an hour a day) of time on travel. We then distributed total travel time for the nation according to State populations raised to the power of 3/2 (see subsection 2.1 and the Appendix).

Having deduced L_{qi} for q = 2 to 5, we calculated the final category of LK use, non-mining private goods (L_{1i}), as a residual from total employment in each State, L_i. Our estimates of total employment were derived from ABS data..

We assume that leisure in each State (C_{2i}, row 19) is approximately 50 per cent of total factor usage in production and travel. Workers on average spend 40 hours in their jobs but could work up to 60 hours a week whilst still having sufficient time for rest. Variations across States in the 50 per cent rule were made in accordance with data on participation rates.

The data on per capita grants to the States from the Commonwealth (H_i/POP, row 21) was obtained from the CGC.

As explained in subsection 2.2, the utility parameters δ_{1i} and δ_{2i} (rows 22 and 23) are shares of the household budget devoted to private goods and to leisure. For calculating the δ_{3gi}s (row 24) from equations 27 to 29 (subsection 2.3), we need quantities (C_{3i}) and costs per unit (W_iA_{3i}) of discretionary State goods. From CGC data we deduced *standardized* expenditures (SSE_{3i}) on these goods, i.e. expenditures required for a State to provide the Australia-wide level of effective per capita consumption, say one unit. We then deduced costs per unit by interpreting SSE_{3i} as the cost in State i of N_i^{θ} units (recall that effective per capita consumption of discretionary State goods is quantity divided by N_i^{θ}). Having deduced costs per unit (shown in row 27 as an index), we obtained actual quantities (C_{3i}) by deflating actual expenditures.

4. Simulation results from CSF

Table 3 reports results from seven CSF simulations for: (a) changes from present levels in grants per capita in each State; (b) percentage changes in populations; (c) changes in per capita welfare in each State measured in dollars per year; and (d) the change in aggregate welfare measured in millions of dollars per year. As described in section 2, we represent the welfare of the typical individual in each State by a utility function. A reallocation of Commonwealth grants produces changes in the provision of discretionary State goods and in State tax rates, inducing changes in the utility levels of typical individuals. We convert these utility changes into money-equivalents through a conversion factor which shows the simulated effect on the utility of the typical individual in each State of a $1 gift. Aggregate welfare is an add-up of the money-equivalent utility effects for the individuals in each State.

The parameters in the first two simulations are set at their default values. Key features of these settings are the following:

- the mobility parameter, d (see subsection 2.5) is set at 1. We judge that this value leads to realistic population movements.
- State government preference parameters for discretionary State goods, δ_{3gi}. Default values are in Table 2 (row 24) and Figure 2.1. Their derivation was explained in subsection 2.3. With the default values, the governments of NT, SA, TAS and QLD have considerably higher preferences for discretionary State goods than do the other governments. Combined with our assumption that households in each State have a preference parameter (δ_3) for discretionary State goods that is the minimum of the δ_{3gi}s, our default values for the δ_{3gi}s imply that the governments of NT, SA, TAS and QLD have considerably higher preferences for discretionary State goods than do their citizens.

- fiscal-externalities or scale-economies parameter, θ. The default value is 1, implying that there are no fiscal externalities or scale economies.
- congestion parameter, γ. This parameter is described in subsection 2.1 and the Appendix. Its default value is 1.5, implying that travel times per person increase in each State with population but that there are no externalities, that is the entire cost of a journey to work is borne by the person making the journey.

In the remaining five simulations, Commonwealth grants are moved from their current distribution to equal per capita. This was also the case in simulation 1. What varies in the inputs to the five simulations is the set of parameter values. Thus by comparing these simulations with simulation 1, we can assess the sensitivity of our results to parameter changes.

Simulation 1. Equal per capita with default parameters

This simulation shows the effects of allocating the present Commonwealth funding of the States on an equal per capita basis. This implies an increase in the per capita grants to NSW, VIC, WA and ACT and decreases for the remaining States, with the decrease for NT being large ($4,785 or 16 per cent of per capita income).

With the default parameter settings used in simulation 1, CSF shows that the introduction of equal-per-capita funding would cause small population changes in all States except the NT. For NT there would be a population reduction of about 11 per cent.

The changes in Commonwealth grants in simulation 1 translate into changes of similar magnitude in the welfare of the typical individual in each State. However, for NT, the loss in welfare for the typical individual ($4,393) is noticeably less than the per capita loss in grant ($4,785). As explained in subsection 2.3, we deduce that the NT government has higher rates of taxes and spending than is optimal for NT households. A small compensation for these households from the loss of Commonwealth funding is that it induces the NT government to cut expenditure of low marginal value. Similarly, SA and TAS households suffer welfare losses that are noticeably less than the amounts of money they give up per capita.

Multiplying State populations by the gaps between the changes in per capita welfare and per capita grants and adding, gives $115 million. To understand that this is a welfare gain, we can think of NT citizens as giving up $4,785 per capita to other Australians but suffering a lose of only $4,393 per capita. The gaps are not the only source of welfare gain. As we will see in simulation 3, welfare is enhanced by the movement of population out of NT into States with lower costs per unit of discretionary State goods. Thus the total welfare gain in simulation 1 is more than $115 million a year, namely $169 million.

Simulation 2. Equal-per-capita funding moderated by real per capita guarantees

The immediate implementation of equal-per-capita funding would create significant adjustment problems in NT and possibly in TAS and SA. Simulation 2 shows the effects of a partial movement towards equal-per-capita funding.

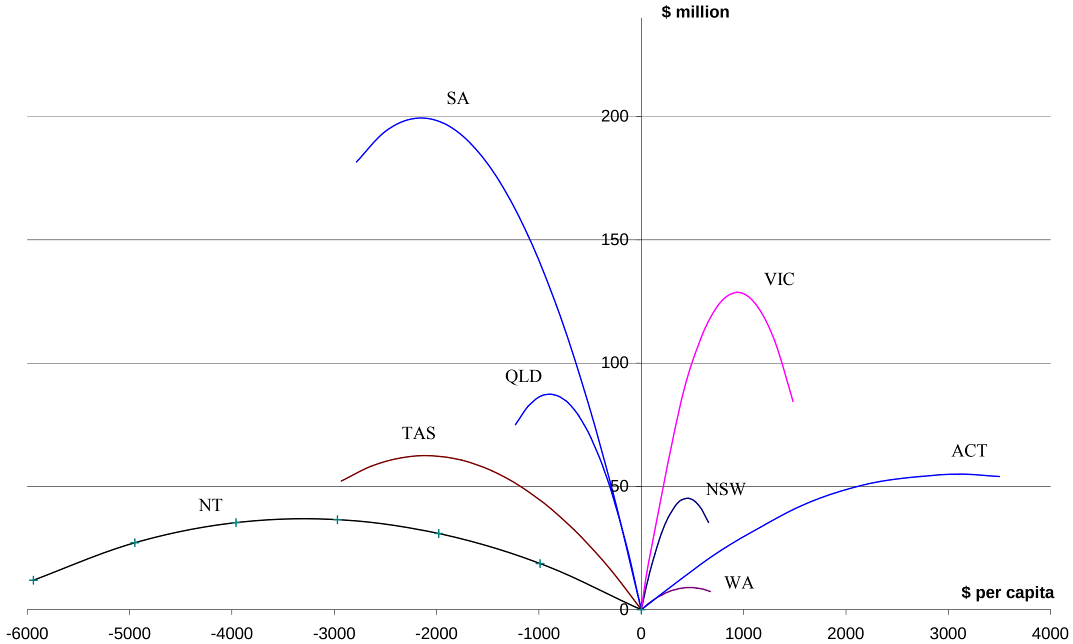
In setting up this simulation, we first calculated the growth in real per capita grants that would take place in the years to 2010-11 under normal growth in real incomes. Then we calculated the deviations from these business-as-usual grants if States enjoying higher-than-average per capita grants had their real per capita grants frozen at their 2000-01 levels. Under this scheme, subsidized States would not face reductions in their real per capita grants. However, they would not receive the increases experienced by other States until their subsidization disappeared. Having calculated these deviations for 2010-11, we scaled them so that they could be applied to CSF with its 2000-01 database. For example, our initial calculations indicated that under this scheme the per capita grant of NT in 2010-11 would be reduced by $2,046 relative to its level under business-as-usual assumptions. We estimate that a per capita reduction of $2,046 in 2010-11 is equivalent to a $1,300 per capita reduction applied to the smaller NT economy of 2000-01. As can be seen from Table 3, the $1,300 reduction is applied in simulation 2.

The most striking result from simulation 2 is that the aggregate welfare gain of $157 million per annum is only slightly less that the that in simulation 1 ($169 million). This is despite the reduction in the per capita grant to NT ($1,300) being only about a quarter of that in simulation 1 ($4,785). Thus it appears that the move from partial implementation of equal-per-capita funding (simulation 2, involving comparatively minor disruption of NT) to full implementation (simulation 1) generates only a small welfare gain.

To help us understand this result we constructed Figure 4.1. The NSW curve in Figure 4.1 shows the effects (under default assumptions) on Australian welfare of relative changes in the per capita grant to NSW. Reading from this curve, we see that if the per capita grant of NSW were increased by $(450 - x) and the per capita grants of other States were reduced by $x where x is calculated so that there is no change in the total grant, then welfare would increase by $45 million. The other curves have similar interpretations.

The NSW curve shows diminishing marginal welfare returns to initial increases in NSW's relative per capita grant from its present level followed eventually by negative marginal returns. As we increase the NSW grant, and simultaneously reduce the grants of other States, Australian welfare increases because the NSW government spends money more closely in accordance with the preferences of its citizens than do most other State governments (δ_{3gNSW} is close to δ_3). However as we make larger and larger increases in the NSW per capita grant, the welfare gains taper off. One reason is travel costs. With ever-increasing population gains, NSW suffers ever-increasing travel costs per capita that are not offset by the ever-decreasing travel costs per capita in other States. However the main reason for the diminishing marginal welfare gains is to do with excess burdens of taxation.

Figure 4.1. Effect on Australian welfare of changes in the per capita grant to each State relative to the per capita grants to other States



With increases in its grant, NSW reduces its tax rate (T_{1NSW}), thereby improving the work/leisure allocation of its citizens. The welfare gain in NSW per percentage point reduction in T_{1NSW} from improved work/leisure allocation is approximately proportional to the total tax rate on wages in the State ($T_{1NSW} + T_C$). Thus the welfare gain in NSW per unit increase in grant declines as the grant increases and T_{1NSW} falls. At the same time, with reduced grants to other States, these States increase their tax rates with ever-increasing marginal losses. The combination of decreasing marginal gains in NSW and increasing marginal losses in other States produces the inverted U-shape shown in Figure 4.1 for NSW.

Similar explanations underlie the inverted U-shapes for the other curves. However, for some States (NSW, VIC, WA and ACT[4]) the inverted U is on the positive side of the vertical axis, indicating that Australian welfare is enhanced by increased grants, while for others (QLD, SA, TAS and NT) the inverted U is on the negative side of the vertical axis, indicating that welfare is enhanced by reduced grants. Whether the inverted U is on the positive or negative side of the vertical axis depends primarily on the δ_{3gi}s. The four States with low δ_{3gi}s (see Figure 2.1) are those for which increased grants generate an Australia-wide welfare increase and the four with high δ_{3gi}s are those for which reduced grants generate an Australia-wide welfare increase. A low δ_{3gi} indicates that the government of State i spends money in accordance with household preferences while a high δ_{3gi} indicates the opposite. Australia-wide welfare is enhanced by reallocations towards governments that spend and tax in accordance with household preferences and away from governments that do not.

By using Figure 4.1 we can make a good estimate of the CSF result for the effect on Australian welfare of any (fixed total) reallocation of grants between the States. For example, the movement in grants from the present system to equal per capita (simulation 1) can be considered as a combination of eight relative per capita movements:$123 to NSW generating an Australia-wide welfare change of $19 million; $198 to VIC generating $40 million; -$36 to QLD generating $6 million; -$304 to SA generating $50 million; $43 to WA generating $2 million; -$697 to TAS generating $33 million; -$4,785 to NT generating $30 million; and $54 to ACT generating $1 million. This gives a total welfare gain for Australia of $181 million, reasonably close to the result in simulation 1, $169 million.

On the basis of the eight curves in Figure 4.1 we can quickly find the reason that the welfare gain in simulation 2 is almost as large as that in simulation 1 despite the relatively mild changes in grants in simulation 2. Looking at the NT curve, we see that the welfare cost of replacing the massive cut for NT in simulation 1 ($4,785) by the much milder cut ($1,300) in simulation 2 is only about $7 million. This is because between the two simulations we go from a cut for NT that is too large to one that is too small. For the other States, the move from simulation 1 to simulation 2 involves small movements either up (QLD and SA) or down (NSW, VIC, WA, TAS and ACT) their inverted U curves.

Simulation 3. Equal-per-capita funding under zero mobility

The changes in Commonwealth per capita funding are the same in this simulation as in simulation 1. However, d in equation 37 has a very high value so that there is no movement of population. Comparing simulations 3 and 1 we see that the welfare effect of equal-per-capita funding responds

[4] Commonwealth expenditures are a very large part of the ACT economy and some of those expenditures may be close substitutes for the ACT government's own expenditure. If this is the case, the underlying quantity of state-government-like services is higher than reflected in CGC figures, so our estimate of δ_{3gACT} may be too low.

quite sluggishly as we go from zero mobility to the default level involving a reduction in the NT population of 10.83 per cent.[5]

Following the argument of Dixon *et al.* (1993), we expected a much stronger response of welfare to mobility than is apparent in simulations 3 and 1. Going from simulation 3 to 1, there is a reduction in the NT population of about 20,000 (10.83 per cent of 190,000). Table 2 (row 27) indicates that the unit cost of discretionary State goods in NT is twice that in other States and that the Australia-wide average cost per capita of these goods is $3,866 (=74.03b/19.15m). This means that the 20,000 people who leave NT in simulation 3 can be provided with the Australia-wide average quantity of discretionary State goods at a cost saving of about $77 million [= 20,000*(2*3866-3866)], raising the question of why the welfare increase as we go from simulation 3 to 1 is only $13 million. The answer is in the first row in Table 2. This shows high relative wages in NT. As people leave NT, the welfare gain associated with reduced Australia-wide costs of discretionary State goods is offset by reduced Australia-wide productivity as high paid Territorians take lower paid jobs in other States.

With no population movement in simulation 3, we expected the gap calculation described in simulation 1 to give a close approximation to the overall welfare gain ($156 million). Consistent with this expectation, multiplying State populations by the gaps between the changes in per capita welfare and per capita grants and adding, gives $157 million.

Simulation 4. Equal-per-capita funding with changes in State government preferences

This simulation is the same as simulation 1 except that we allow the parameters of the State governments' utility functions to be influenced by the Commonwealth grants. As explained in subsection 2.3, we deduce that the NT government behaves as if the utility derived from discretionary State goods is considerably in excess of the utility actually derived by NT households. Here we assume that a sharp reduction in Commonwealth funding causes the NT government to adjust its valuation of government services towards the valuation placed on these services by households. This leads the NT government to adopt behaviour that is closer to optimizing behaviour from the point of view of households.

The changes ($\Delta\delta_{3gi}$) in State government utility parameters in this simulation are shown in Table 2, row 26. In calculating these changes we assumed that the move to equal-per-capita funding forces the δ_{3gi} for NT to the same value as that for SA (the State with the second highest initial δ_{3gi}). We then calculated the implied rate of adjustment in δ_{3gNT} per dollar of per capita grant loss and assumed that this rate of adjustment applies to all the δ_{3gi}s. As can be seen from Table 2, our assumptions for the δ_{3gi}s generate small increases for NSW, VIC, WA and ACT. For these States the move to equal-per-capita funding allows a small relaxation of fiscal discipline. For QLD there is a small reduction in δ_{3gi} corresponding to a small tightening in fiscal discipline. For SA, TAS and especially NT there are significant reductions in the δ_{3gi}s. The reductions in grants for these States are sufficiently large to cause major reassessments by their governments of the value of public spending.

The movement in the preferences of the NT government towards those of its households generates a considerable utility gain. In simulation 1, the per capita grant reduction of $4,785 in NT imposed a per capita welfare loss on NT households of $4,393. Now the per capita welfare loss on NT households is only $4,077. The gains for NT households as we move from simulation 1 to simulation 4, and the smaller but noticeable gains for the households of SA, TAS and QLD, are not

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[5] The welfare response continues to be sluggish with high mobility. In an equal-per-capita simulation in which the NT population fell by 21 per cent, the welfare gain rose to only $181 million.

offset by the tiny losses for the other States. This leaves the overall effect on Australian welfare in simulation 4 considerably higher than in simulation 1, $259 million compared with $169 million.

Given the way that we adjusted the δ_{3gi}s, it is apparent that the population-weighted average adjustment is close to zero. The reason that gains in simulation 4 are not offset by losses can be traced to ideas from "envelope" theorems. In simulation 4, increases in δ_{3gi}s are being imposed in States where the initial values are close to optimal. Thus in these States the rate of welfare loss per unit increase in the δ_{3gi}s is low. On the other hand, decreases in the δ_{3gi}s are being imposed in States where the initial values are well above optimal. Thus in these States the rate of welfare gain per unit decrease in the δ_{3gi}s is high.

Simulation 5. Equal-per-capita funding with fiscal externalities

Here we set θ (see subsection 2.2) at 0.5 instead of 1. A value of 0.5 means that a 1 per cent increase in population requires only a 0.5 per cent increase in the resources devoted to discretionary State goods to maintain the initial effective level of per capita consumption.

With fiscal externalities, there are cost decreases in the provision of public goods in the winning States and cost increases in the losing States. This accentuates welfare gains and losses. For example, in simulation 1 (where there were no fiscal externalities, $\theta = 1$), the per capita welfare loss in NT was $4,393. Now, in simulation 5, the increase in costs per capita of discretionary State goods leaves NT households with a per capita welfare loss of $4,620. On the other hand, as we go from simulation 1 to 5 the per capita welfare gains in NSW and VIC increase. Overall, the gains and the losses roughly balance. Australian welfare is slightly higher in simulation 5 than in 1, $177 million compared with $169 million.

Simulations 6 and 7. Equal-per-capita funding with negligible welfare gain

All of the previous simulations concerned with the effects of equal-per-capita funding show significant welfare gains, ranging from $156 million in simulation 3 to $259 million in simulation 4. Simulations 6 and 7 are designed to answer the question: what do we have to assume to produce a negligible welfare gain from equal-per-capita funding?

One possibility is to assume that there are congestion externalities. We do this in simulation 6 by setting the parameter γ (see subsection 2.1) at 2.5 rather than 1.5. As derived in the Appendix, when γ is 2.5, the increase in the total costs of travel caused by a new member of the population is twice the member's private costs.

In earlier simulations we assumed that people in the more populous States face significant costs in travelling to work and that people from other States contemplating a move to the populous States take these costs into account in making location decisions. In simulation 6, private location decisions are modelled in the same way as in the earlier simulations and the mobility parameter (d) is set at its default value. Thus the results for the population changes in simulations 6 and 1 are similar. However, in simulation 6 (unlike simulation 1) we assume that people arriving in the more populous States not only suffer private travel costs in their new environments but they also impose congestion costs on the incumbent population. This is the source of the sharp overall welfare reduction in simulation 6 relative to 1 ($43 million compared with $169 million).

Perhaps the most important implication of simulation 6 is that the welfare gain from moving to equal-per-capita funding remains positive despite the imposition of savage congestion externalities. By comparing the results for simulations 6 and 1, we see that the externalities imposed in simulation 6 reduce per capita welfare gains in NSW and VIC by $11 and $15. Using the population numbers in Table 2 and the population changes in Table 3 for simulation 6, we calculate that in simulation 6 the congestion externalities for NSW and VIC are about $3,500 and $2,900 per new arrival. These figures seem unrealistically large, and make simulation 6 unrealistically pessimistic.

Another way in which we can obtain a negligible welfare gain in an equal-per-capita simulation is to assume that household and State government utility parameters coincide. We did this in simulation 7 by altering the exponents on (C_{3i} / N_i^{θ}) in the household utility functions to bring them in line with the δ_{3gi}s. As can be seen from simulation 7, when we assume that State government expenditure and tax decisions are designed to maximize household welfare (not State government welfare) then there is no overall gain from moving to equal-per-capita grants. As emphasized throughout the discussion of Table 3, the major source of gain from reducing subsidization in the allocation of grants is that it will take money away from State governments that do not spend it in accordance with household preferences and/or force government preferences to change towards those of households.

Because there is convincing evidence that the heavily subsidized States (particularly NT) have tax and expenditure patterns that do not reflect household preferences, the welfare result in simulation 7 does not seriously threaten the conclusion that a move to equal-per-capita funding would be welfare enhancing.

5. Concluding remarks

Our results indicate that the annual welfare gain from a change to equal-per-capita funding is likely to be between \$150 million and \$250 million. Such a change can, therefore, be regarded as a medium-sized microeconomic reform, ranking in significance between the ANTS package of 1998 and the proposed cut (from 15 to 5 per cent) in car tariffs of 1997. Application of similar modelling approaches to our own produced welfare gains for the ANTS package of \$700 million a year in 2000-01 prices (Murphy, 1999) and \$100 million a year in 2000-01 prices for the proposed tariff cut (Industry Commission, 1997).

While the gains reported in this paper are quite large it is apparent from the analysis in section 4 that they are not the largest gains that could be generated by reallocations of Commonwealth funding. In other words, it is apparent that neither equal-per-capita nor State-of-origin funding is optimal. Using Figures 4.1 to 4.8 we can design a package of reallocations that yields much larger gains by choosing for each State the relative change in grant per capita that coincides with the top of the State's inverted U welfare line. After adjustments to produce a package maintaining the current level of overall grant (\$46.7 billion) we obtained a welfare gain of \$536 million. Caution should be exercised in interpreting this simulation given that Figures 4.1 to 4.8 are drawn for a fixed value of the state governments' δ_{3gi}s and that the changes to the existing pattern of grants are very large. At least for large changes in grants we would expect at least some of the "cold shower" effect seen in simulation 4 to occur. Finding the optimal package of grant reallocations would involve adjustment of both grants and the δ_{3gi}s. Thus \$536 million welfare gain should be considered a lower bound on the welfare gain that could be obtained by finding and implementing the optimal package of grant reallocations. The reason for this is that an optimum reallocation of grants from the current system is the combination of two changes: the first being a reallocation of grants holding state government behaviour constant; the second a further reallocation taking account of changes in government preferences. Since both changes involve an improvement in resource use, the welfare gain must be at least \$536 million.

In any modelling exercise there is uncertainty about data, theoretical specifications and parameter values. To cope with this, we have devoted considerable energy to identifying the database items and theoretical mechanisms that are critical to our results. Several conclusions emerge. First, the most important assumption underlying our welfare estimates is that subsidized States (NT, SA and TAS) make spending and tax decisions out of line with household preferences. The evidence is that SA and TAS both provide high quantities of State government goods per capita and NT provides normal quantities despite very high unit costs. If subsidization were reduced, then welfare would be enhanced in two ways. First, money would be diverted to States where it is used more closely in accordance with household preferences. Second, as the subsidized States found themselves having to rely more heavily on own-source revenue, it is likely that their governments, in making tax-expenditure decisions, would become more sensitive to the preferences of households.

Other conclusions from our detailed examination of the results include the following. The welfare gains associated with equal per capita funding: (a) are not seriously reduced by giving a real per capita guarantee; (b) are not very sensitive to mobility assumptions; and (c) are not sensitive to assumptions concerning scale economies in the provision of State government goods. We traced conclusion (a) to the idea that equal-per-capita funding overshoots the optimal reduction in NT per capita grant. Conclusion (b) comes from the idea that movements in population out of NT have two roughly offsetting welfare effects. On the one hand, when people leave NT the cost of providing them with State goods is reduced. On the other hand, reflecting our data which show high real wages in NT, reductions in the NT population have a negative impact on overall Australian productivity. Conclusion (c) follows because the cost reductions in the provision of State goods arising from scale economies in States benefiting from grant reallocation are offset by cost increases in States that are harmed by grant reallocation.

One possible justification of the present system of grant allocation is that it reduces population in Australia's largest cities, Sydney and Melbourne. Using CSF we showed that even with seemingly extreme assumptions concerning negative congestion externalities, the adoption of equal-per-capita funding would nevertheless have a positive welfare impact.

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Appendix. Travel to work, congestion costs and the rental value of land

We imagine that all the people in a State reside in a circular city (Figure A1) and that each person requires one unit of land. Thus we assume that State population (N) and city radius (B) are related by: $N = \pi B^2$. Next we assume that each person travels daily to work in the centre of the city via the travel channel through his or her segment. Thus all the people in the segment bounded by OB and OC use the travel channel OF and all the people in the area ABCD pass daily through point G. If there are M equally spaced radial travel channels then the number of people N_q passing daily through the q-circle on any channel is given by

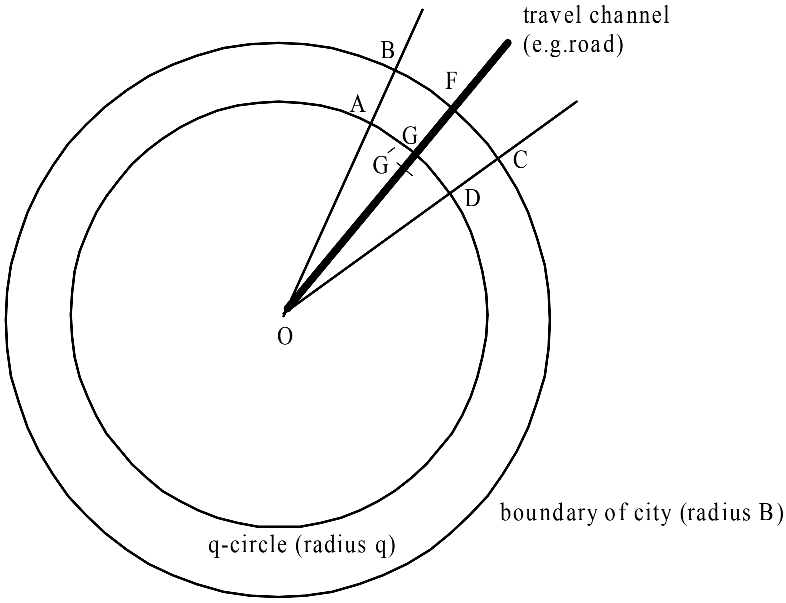
$$N_q = (1/M)\pi(B^2 - q^2) = (1/M)(N - \pi q^2).$$

We assume that people on any circle travel at no cost around their circle to their closest travel channel. When the people on the q-circle arrive at their closest travel channel they join a traffic flow of N_q people per day. Next we assume that the time taken by a person to progress one unit of distance from the q-circle along a travel channel towards the city (from G to G' for example) is non-negatively related to the density of traffic flow, N_q. In particular we assume that this travel time is βN_q^ϕ where $\phi \geq 0$ and $\beta > 0$. Under this assumption, daily travel time (T_q) for a person from the q-circle and total travel time for the city (T_{TOT}) are

$$T_q = \int_0^q \beta N_x^\phi dx \qquad \text{and} \qquad T_{TOT} = \int_0^B T_q 2\pi q dq \ .$$

In calculating the rental value of land, we assume that land on the boundary circle has no value and that the value of land on the q-circle reflects the value of travel time for a person from the boundary

Figure A1. The circular city



to the q-circle. Thus, where W_t is the after-tax wage rate, the rental value (R_q) of a unit of land on the q-circle and the rental value of all land (R_{TOT}) are given by

$$R_q = W_t \int_q^B \beta N_x^\phi \, dx \qquad \text{and} \qquad R_{TOT} = \int_0^B R_q 2\pi q \, dq \ .$$

Evaluation of total travel time (T_{TOT}) and total rentals (R_{TOT}) is straightforward in two cases, $\phi = 0$ and $\phi = 1$, and leads to the formulas in Table A1. With $\phi = 0$ there are no externalities. Travel time from the q-circle for one unit of distance towards the centre for any person is β and is independent of the number of people travelling. With $\phi = 1$ there are strong externalities. Travel time from the q-circle for one unit of distance towards the centre for any person is βN_q. This means that an increase of one per cent in the number of people travelling a unit of distance from the q-circle towards the centre imposes a one per cent increase in the travel time for this distance on all people travelling through the q-circle.

The role of externalities when $\phi = 1$ can be seen from the formulas for T_q and T_{TOT} in the right panel of Table A1. By putting $q = B = (N/\pi)^{0.5}$ in the formula for T_q, we find for a person arriving in the city and settling on the boundary that travel time is $\left(2\beta/3M\pi^{0.5}\right) * N^{1.5}$. By differentiating T_{TOT} with respect to N we find that the increase in travel time for the city caused by the person's arrival is $\left(4\beta/3M\pi^{0.5}\right) * N^{1.5}$. Thus the increase in the total travel costs caused by a unit increase in population is twice the private costs incurred by the new member of the population.

In the simulations in section 4 we adopted the values of 0 or 1 for ϕ. Then on the basis of the T_{TOT} and R_{TOT} formulas in Table A1, we assumed that labour time used in work-related travel and the rental value of land are proportional to population raised to the power 1.5 or 2.5, that is in equations 6 and 17 we set $\gamma = 1.5$ or 2.5. On the basis of the T_q formulas,

Table A1. Formulas for travel and land rents in a circular city

Travel externality parameter	$\phi = 0$	$\phi = 1$
Travel time for a person on the q-circle (T_q)	βq	$\frac{\beta\pi}{M} * \left(\frac{Nq}{\pi} - \frac{q^3}{3}\right)$
Total travel time for all people in the city (T_{TOT})	$\frac{2\beta}{3\pi^{0.5}} * N^{1.5}$	$\frac{8\beta}{15M\pi^{0.5}} * N^{2.5}$
Rental value of a unit of land on the q-circle (R_q)	$W_t\beta\left[\left(\frac{N}{\pi}\right)^{0.5} - q\right]$	$\frac{W_t\beta\pi}{M}\left(\frac{2}{3}\left(\frac{N}{\pi}\right)^{1.5} - \left(\frac{N}{\pi}\right)q + \frac{q^3}{3}\right)$
Total rental value of all land in the city (R_{TOT})	$\frac{W_t\beta}{3\pi^{0.5}} * N^{1.5}$	$\frac{2W_t\beta}{15M\pi^{0.5}} * N^{2.5}$

with $q = B = (N/\pi)^{0.5}$, we assumed in equation 33 that travel time for a boundary dweller is proportional to population raised to the power $\gamma - 1$, that is 0.5 if $\phi = 0$ and 1.5 if $\phi = 1$. Finally, in evaluating A_{B6i} in equation 33 we compared the formulas for total travel time and travel time for a boundary dweller. This led us to set A_{B6i} at 3/2 times the value of the coefficient A_{6i} in equation 6 when $\phi = 0$, and at 5/4 times the value of A_{6i} when $\phi = 1$.

Table 1. Equations of the CSF model [(a)]

1	$L_{1i} = \mathbf{A}_{1i} Y_{1i}$
2	$Y_{2i} = (1/\mathbf{A}_{2i}) L_{2i}^{\boldsymbol{\alpha}_i} \mathbf{R}_i^{1-\boldsymbol{\alpha}_i}$
3	$L_{3i} = \mathbf{A}_{3i} C_{3i}$
4	$L_{4i} = \mathbf{A}_{4i} \mathbf{C}_{4i}$
5	$L_{5i} = \mathbf{A}_{5i} \mathbf{C}_{5i}$
6	$L_{6i} = \mathbf{A}_{6i} N_i^{\boldsymbol{\gamma}}$
7	$L_i = \sum_{q=1}^{6} L_{qi}$
8	$C_{2i} = N_i - L_i$
9	$\mathbf{N} = \sum_i N_i$
10	$W_i = 1/\mathbf{A}_{1i}$
11	$W_i L_{2i} = \boldsymbol{\alpha}_i Y_{2i},$
12	$Q_i \mathbf{R}_i = (1 - \boldsymbol{\alpha}_i) Y_{2i}$
13	$U_{hi} = (C_{1i}/N_i)^{\boldsymbol{\delta}_{1i}} (C_{2i}/N_i)^{\boldsymbol{\delta}_{2i}} \left(C_{3i} / N_i^{\boldsymbol{\theta}}\right)^{\boldsymbol{\delta}_3}$
14	$B_i = W_{ti}(N_i - L_{6i}) + \mathbf{BENRATE}_i * N_i + \mathbf{S} * NMR(N_i/\mathbf{N}) - \mathbf{T}_{3i} OD_i$
15	$W_{ti} = W_i (1 - T_{1i} - T_C)$
16	$NMR = \sum_i Q_i \mathbf{R}_i * (1 - \mathbf{T}_{2i})$
17	$OD_i = \mathbf{A}_{7i} W_i N_i + \mathbf{A}_{8i} W_{ti} N_i^{\boldsymbol{\gamma}}$
18	$C_{1i} = \boldsymbol{\delta}_{1i} B_i$
19	$C_{2i} = \boldsymbol{\delta}_{2i} (B_i / W_{ti})$
20	$del\_U_{tot} = \sum_i N_i^{ave} * \mathbf{A}_{ui} * del\_U_{hi},$
21	$N_i^{ave} = (\mathbf{NBASE}_i + N_i)/2$
22	$del\_U_{hi} = U_{hi} - \mathbf{UBASE}_{hi}$
23	$U_{gi} = (C_{1i}/N_i)^{\boldsymbol{\delta}_{1i}} (C_{2i}/N_i)^{\boldsymbol{\delta}_{2i}} \left(C_{3i} / N_i^{\boldsymbol{\theta}}\right)^{\boldsymbol{\delta}_{3gi}}$
24	$\mathbf{SB}_i = SR_i + H_i - SE_i$
25	$SR_i = T_{1i} W_i (L_i - L_{6i}) + \mathbf{T}_{2i} Q_i \mathbf{R}_i + \mathbf{T}_{3i} OD_i$
26	$SE_i = \mathbf{A}_{3i} W_i C_{3i} + W_i L_{4i}$
27	$\Lambda_{1i} = -\Lambda_{2i} \boldsymbol{\delta}_{2i} T_{1i} / (1 - T_{1i} - T_C) + (\boldsymbol{\delta}_{1i}/N_i)^{\boldsymbol{\delta}_{1i}} (\boldsymbol{\delta}_{2i}/N_i W_{ti})^{\boldsymbol{\delta}_{2i}} \left(C_{3i} / N_i^{\boldsymbol{\theta}}\right)^{\boldsymbol{\delta}_{3gi}}$
28	$\Lambda_{2i} = \boldsymbol{\delta}_{3gi} \left(B_i / (N_i^{\boldsymbol{\theta}} A_{3i} W_i)\right) * (\boldsymbol{\delta}_{1i}/N_i)^{\boldsymbol{\delta}_{1i}} (\boldsymbol{\delta}_{2i}/N_i W_{ti})^{\boldsymbol{\delta}_{2i}} \left(C_{3i} / N_i^{\boldsymbol{\theta}}\right)^{\boldsymbol{\delta}_{3gi}-1}$
29	$\boldsymbol{\delta}_{2i} B_i \left(\frac{\boldsymbol{\delta}_{1i}}{N_i}\right)^{\boldsymbol{\delta}_{1i}} \left(\frac{\boldsymbol{\delta}_{2i}}{N_i W_{ti}}\right)^{\boldsymbol{\delta}_{2i}} \left(\frac{W_i}{W_{ti}}\right) \left(\frac{C_{3i}}{N_i^{\boldsymbol{\theta}}}\right)^{\boldsymbol{\delta}_{3gi}} = \Lambda_{1i} W_i (N_i - L_{6i}) + \Lambda_{2i} \left(\frac{\boldsymbol{\delta}_{2i} B_i W_i^2 T_{1i}}{W_{ti}^2} - (N_i - L_{6i} - \frac{\boldsymbol{\delta}_{2i} B_i}{W_{ti}}) W_i\right)$
30	$H_i / N_i = \mathbf{FHN}_i * FFHN$
31	$\mathbf{H} = \sum_i H_i$
32	$B_i^m = \mathbf{S} * NMR/\mathbf{N} + \mathbf{BENRATE}_i + \sum_k OD_k (1 - \mathbf{T}_{3k})/\mathbf{N} + W_{ti}(1 - LB_{6i})$
33	$LB_{6i} = \mathbf{A}_{B6i} N_i^{\gamma - 1}$
34	$C_{1i}^m = \boldsymbol{\delta}_{1i} B_i^m$
35	$C_{2i}^m = \boldsymbol{\delta}_{2i} B_i^m / W_{ti}$
36	$C_{3i}^m = C_{3i} / N_{\mathbf{i}}^{\boldsymbol{\theta}}$
37	$U_i^m = \left(C_{i1}^m\right)^{\boldsymbol{\delta}_{1i}} \left(C_{2i}^m\right)^{\boldsymbol{\delta}_{2i}} \left(C_{3i}^m\right)^{\boldsymbol{\delta}_3} \left(\frac{N_i}{\mathbf{NBASE}_i}\right)^{-\mathbf{d}}$
38	$U_i^m = U * \mathbf{FUM}_i$
39	$\mathbf{FB} = \sum_i T_C W_i (L_i - L_{6i}) - \sum_i L_{5i} W_i - \mathbf{H} - \sum_i \mathbf{BENRATE}_i * N_i$

[(a)] Parameters and exogenous variables are shown in bold type and notation is defined in the text.

Number of equations = number of endogenous

Table 2. Selected data items used in the CSF model: 2000-01

			NSW	VIC	QLD	SA	WA	TAS	NT	ACT	total
1	Pre-tax wage rate of LK composite	W_i	1.000	0.983	0.811	0.764	0.974	0.721	1.090	1.010	
2	State tax rates on LK composite	T_{1i}	0.053	0.063	0.070	0.077	0.041	0.055	0.034	0.036	
3	Commonwealth tax rates on LK	T_C	0.310	0.310	0.310	0.310	0.310	0.310	0.310	0.310	
4	Post tax wage rate	W_{ti}	0.637	0.617	0.503	0.468	0.632	0.457	0.715	0.660	
5	Mining rent \$b	Q_iR_i	1.700	0.255	3.105	0.698	4.432	0.082	1.200	0.001	11.472
6	State tax rates on mining rent	T_{2i}	0.125	0.073	0.177	0.106	0.100	0.142	0.020	0.000	
7	State tax rates on housing and land	T_{3i}	0.125	0.130	0.108	0.093	0.158	0.072	0.093	0.110	
8	Returns to buildings \$b	$A_{7i}W_{ti}N_i$	9.034	6.550	4.044	1.599	2.562	0.474	0.297	0.439	24.999
9	Returns to unimproved land \$b	$A_{8i}W_{ti}N_i^{\gamma}$	16.267	6.550	4.356	2.101	1.938	0.447	0.113	0.561	32.331
10	Total use of LK composite \$b	W_iL_i	209.24	153.22	94.79	35.66	62.96	9.85	6.86	11.68	584.25
11	private goods, non-mining	W_iL_{1i}	137.45	102.96	57.83	22.29	30.56	6.10	1.51	0.98	359.68
12	private goods, mining	W_iL_{2i}	1.69	3.09	4.03	0.40	15.15	0.17	2.07	0.00	26.59
13	State government, discretionary	W_iL_{3i}	23.50	16.87	13.96	6.96	7.99	2.02	1.51	1.23	74.03
14	State government, non-discretionary	W_iL_{4i}	3.23	1.96	2.12	0.79	1.08	0.33	0.39	0.10	9.99
15	Commonwealth government	W_iL_{5i}	14.14	9.86	6.96	2.86	3.30	0.88	1.21	8.99	48.20
16	work-related travel	W_iL_{6i}	29.24	18.47	9.90	2.35	4.89	0.35	0.17	0.38	65.75
17	Population, millions	POP	6.46	4.76	3.57	1.50	1.88	0.47	0.19	0.31	19.15
18	Population, CSF units	N	316.25	233.16	174.49	73.30	92.14	23.00	9.54	15.22	937.10
19	Leisure, CSF units	C_{2i}	107.01	77.37	57.66	26.62	27.47	9.33	3.25	3.65	312.37
20	Employment, CSF units	L_i	209.24	155.79	116.83	46.68	64.67	13.67	6.29	11.57	624.74
21	Commonwealth grants per capita (\$)	H_i/POP	2316	2241	2475	2743	2396	3125	7227	2386	
	Utility parameters										
22	Household & State gov, private goods	δ_{1i}	0.6644	0.6765	0.6890	0.6758	0.7136	0.6504	0.6752	0.7732	
23	Household & State gov, leisure	δ_{2i}	0.3356	0.3235	0.3110	0.3242	0.2864	0.3496	0.3248	0.2268	
24	State gov., discretionary State goods	δ_{3gi}	0.1162	0.1150	0.1508	0.1831	0.1322	0.1670	0.2119	0.1158	
25	Household, discretionary State goods	δ_3	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115	
26	Changes in disc. State goods, sim. 4	$\Delta\delta_{3gi}$	0.0008	0.0013	-0.0002	-0.0019	0.0003	-0.0044	-0.0307	0.0003	
27	Cost per unit of discret. State goods	W_iA_{3i}	1.000	0.957	0.968	1.010	1.068	1.059	2.027	1.060	

Table 3. Effects of changes in Commonwealth grants to the States: Results from CSF

	Aggregate. Welfare ($mill)		NSW	VIC	QLD	SA	WA	TAS	NT	ACT
1: Equal per capita Default parameters	169	change in grant per capita ($)	123	198	-36	-304	43	-687	-4785	54
		change in population (%)	0.32	0.54	-0.12	-0.93	0.10	-2.13	-10.83	0.13
		change in per capita welfare ($)	121	196	-35	-276	41	-641	-4393	53
2: Equal per capita moderated by real per capita guarantee Default parameters	157	change in grant per capita ($)	85	172	-93	-359	28	-515	-1300	-116
		change in population (%)	0.24	0.48	-0.28	-1.08	0.08	-1.58	-2.89	-0.30
		change in per capita welfare ($)	85	172	-86	-324	29	-478	-1170	-113
3: Equal per capita(a) Zero mobility	156	change in population (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		change in per capita welfare ($)	124	199	-35	-279	42	-644	-4328	54
4: Equal per capita(a) State government preference change	259	change in population (%)	0.32	0.54	-0.13	-0.91	0.09	-2.11	-10.24	0.12
		change in per capita welfare ($)	120	196	-33	-262	40	-616	-4077	53
5: Equal per capita(a) Fiscal externalities	177	change in population (%)	0.34	0.58	-0.13	-0.98	0.11	-2.26	-11.46	0.14
		change in per capita welfare ($)	126	206	-36	-289	42	-673	-4620	55
6: Equal per capita(a) Congestion externality	43	change in population (%)	0.31	0.52	-0.10	-0.89	0.11	-2.09	-10.69	0.14
		change in per capita welfare ($)	110	181	-34	-268	37	-633	-4341	49
7: Equal per capita(a) Identical Household & State gov. utility	-4	change in population (%)	0.35	0.57	-0.09	-1.01	0.14	-2.31	-12.32	0.16
		change in per capita welfare ($)	145	233	-46	-406	47	-925	-5747	53

(a) Changes in grants per capita are the same as in simulation 1.